

The Efficacy of Adding a Minimum Adjusted Fat Thickness Requirement to the USDA Beef Quality Grading Standards for Select Grade Beef¹

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ABSTRACT: The present analysis was conducted to test the efficacy of adding a minimum 5-mm adjusted s.c. fat thickness requirement to the present USDA beef quality grading standards for the Select grade. Carcass grade data and longissimus thoracis Warner-Bratzler shear force and trained sensory panel ratings were analyzed for calf-fed steers ($n = 1,602$). The experimental group (nine breeds and three composite populations finished on medium- and high-energy diets) contained a large amount of variation in yield grade, marbling score, Warner-Bratzler shear force, and sensory panel overall tenderness ratings ($CV = 30.8, 17.9, 25.0$, and 14.0% , respectively). All but one of the carcasses were of A maturity and 37% of the carcasses had < 5 mm adjusted fat thickness. Among carcasses with a "slight" amount of marbling,

WBS values were higher (5.58 vs 5.32 kg; $P < .01$) and overall tenderness (4.82 vs 4.99 ; $P < .01$) was lower for carcasses with < 5 mm s.c. fat thickness than for those with ≥ 5 mm s.c. fat thickness. However, the magnitude of those differences was so small that the current and proposed Select grades did not differ with respect to shear force (5.45 vs 5.32 kg), overall tenderness (4.90 vs 4.99), juiciness (5.09 vs 5.12), beef flavor intensity (4.86 vs 4.86), or the percentage of samples rated "slightly tender" or higher for overall tenderness (48.7 vs 52.0). Thus, it seems that the addition of a minimum fat thickness requirement to the standards for the Select grade would not improve the tenderness of Select grade longissimus thoracis steaks.

Key Words: Beef, Carcass Grading, Fat Thickness, Meat Quality, Palatability, Tenderness

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Introduction

Recent surveys have indicated that there is an excessive amount of variation in the tenderness of beef cuts at the retail and foodservice level (Morgan et al., 1991; Hamby, 1992). Moreover, these surveys have revealed the inability of the current USDA beef quality grading system to accurately segregate carcasses into expected palatability groups. Thus, in 1992, the Grading Committee of the National Cattle-men's Association formed a Carcass Quality Task Force (CQTF) to examine possible changes to the present USDA beef quality and yield grading system.

In addition to the present maturity-marbling restrictions placed on the Select grade (USDA, 1989),

the CQTF considered to propose that carcasses be required to have adjusted s.c. fat thickness of at least 5 mm to grade Select. The present analysis was conducted to test the efficacy of adding a minimum 5-mm adjusted fat thickness requirement to the present USDA beef quality grading standards for the Select grade using diverse biological types of steers.

Materials and Methods

Animals. The carcasses ($n = 1,602$) used in this experiment were from the Germplasm Utilization (GPU) project at the Roman L. Hruska U.S. Meat Animal Research Center (MARC). Experimental design and carcass handling procedures have been reported previously (Gregory et al., 1994). The GPU project consisted of purebred Angus (A), Braunvieh (B), Charolais (C), Gelbvieh (G), Hereford (H), Limousin (L), Pinzgauer (P), Red Poll (RP), and Simmental (S) and three composite populations; MARC I (1/4 C, 1/4 B, 1/4 L, 1/8 H, 1/8 A), MARC II (1/4 S, 1/4 G, 1/4 H, 1/4 A), and MARC III (1/4 RP, 1/4 H, 1/4 P, 1/4 A).

¹Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of other products that may also be suitable. The authors are grateful to Carol Grummert for her secretarial assistance.

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Steers were fed a corn-corn silage diet from weaning to slaughter at 361 to 515 d of age. The length of the feeding period ranged from 249 to 343 d. Cattle were slaughtered and processed commercially. Immediately after slaughter and dressing, carcass sides were electrically stimulated (68 V, 3 s on, 3 s off; 70 V, 2 s on, 3 s off; 70 V, 2 s on, 3 s off; 70 V, 2 s on, 3 s off) and chilled (24 h at 0°C). A spray-chilling system, which involved spraying carcasses with a fine mist of 2°C water for 30 s every 5 min, was employed. Spray-chilling was terminated at approximately 12 h postmortem. Following chilling, carcasses were ribbed and USDA quality and yield grade were determined.

At 36 h postmortem, carcasses were transported to MARC and longissimus thoracis (LT) steaks (thickness = 2.54 cm) were removed for Warner-Bratzler shear (WBS) force and trained sensory panel (TSP) analyses, respectively. Steaks were vacuum-packaged and aged until 9 d postmortem and then frozen and stored for up to 6 mo before they were thawed and cooked. For both WBS and TSP, steaks were thawed for 24 h at 4°C, broiled to an internal temperature of 40°C, turned, and broiled to a final internal temperature of 70°C. For WBS determination, steaks were placed in polyvinyl chloride bags and cooled for 24 h at 4°C before removal of six cores (diameter = 1.27 cm) parallel to the longitudinal orientation of the muscle fibers. Each core was sheared once with a WBS attachment using an Instron Universal Testing Machine (Instron Corp., Canton, MA). For TSP evaluation, steaks were held in a warming oven at 70°C for up to 30 min before they were sliced and served. Each panelist received three cubes (1.3 cm × 1.3 cm × cooked steak thickness) from each carcass. Sensory panelists rated steaks for overall tenderness, juiciness, and beef flavor intensity on an 8-point scale (1 = extremely tough, dry, and bland and 8 = extremely tender, juicy, and intense). The eight-member sensory panel was trained and selected according to Cross et al. (1978) and was highly experienced (average experience level was 5.6 yr and the range was from 1 to 9 yr) before the initiation of this experiment and remained intact for all 4 yr of this experiment.

Statistical Analysis. Cattle were segregated into two classes based on adjusted s.c. fat thickness at the 12th rib (< 5 mm vs ≥ 5 mm) and four classes based on marbling score (traces or lower, slight, small, and modest or higher) and an ANOVA was conducted for a 2 × 4 factorially arranged experiment. One-way ANOVA were conducted to assess the effects of fat thickness within each marbling score and across marbling scores. Similarly, one-way ANOVA were conducted to assess the effect of marbling score within each fat thickness group and across both fat thickness groups.

Results

Means, SD, and ranges of the carcass and sensory characteristics of the carcasses used in this analysis

Table 1. Simple statistics of carcass and meat characteristics

Characteristic	Mean	SD	Range
Hot carcass wt, kg	335.2	40.3	218.6–490.5
Actual fat thickness, mm	7.1	4.3	.0–25.4
Adjusted fat thickness, mm	6.5	4.5	1.3–25.4
Longissimus muscle area, cm ²	78.6	10.4	50.3–117.4
Kidney, pelvic, and heart fat, %	2.8	.7	.5–5.0
USDA yield grade	2.6	.8	.1–5.9
USDA maturity score ^a	152.3	12.4	125.0–200.0
USDA marbling score ^b	395.0	70.7	190.0–790.0
USDA quality grade ^c	679.9	45.4	545.0–830.0
Shear force, kg	5.2	1.3	2.3–11.6
Overall tenderness ^d	5.0	.7	2.1–6.9
Juiciness ^e	5.2	.5	3.5–7.1
Beef flavor intensity ^f	4.9	.4	2.9–6.4

^aMaturity score: 100 = A⁰⁰, 200 = B⁰⁰.

^bMarbling score: 100 = practically devoid⁰⁰; 200 = traces⁰⁰; 300 = slight⁰⁰; 400 = small⁰⁰; 500 = modest⁰⁰; 600 = moderate⁰⁰; 700 = slightly abundant⁰⁰; 800 = moderately abundant⁰⁰; 900 = abundant⁰⁰.

^cQuality grade: 500 = Standard⁰⁰; 600 = Select⁰⁰; 700 = Choice⁰⁰; 800 = Prime⁰⁰.

^d8 = extremely tender; 1 = extremely tough.

^e8 = extremely juicy; 1 = extremely dry.

^f8 = extremely intense; 1 = extremely bland.

are reported in Table 1. The experimental group contained a large amount of variation in carcass cutability estimates, marbling score, quality grade, WBS force, and TSP ratings. However, it should be noted that all but one of the carcasses were of A maturity as the steers ranged from 361 to 515 d of age at slaughter. Thirty-seven percent of the carcasses had < 5 mm adjusted fat thickness. Mean actual (3.4 vs 9.2 mm) and adjusted fat thickness (2.5 vs 8.8 mm), hot carcass weight (327 vs 339 kg), kidney, pelvic, and heart fat content (2.6 vs 2.9%), USDA yield grade (1.9 vs 3.0), and marbling score (Slight⁵⁵ vs Small¹⁸) were lower and LT area (82.0 vs 76.7 cm²) was greater for those carcasses with < 5 mm adjusted fat thickness than for those carcasses with ≥ 5 mm adjusted fat thickness ($P < .0001$; data not presented in tabular form). For Select carcasses, mean actual (3.5 vs 7.9 mm) and adjusted fat thickness (2.5 vs 7.5 mm), hot carcass weight (328 vs 335 kg), kidney, pelvic, and heart fat content (2.6 vs 2.7%), USDA yield grade (1.9 vs 2.7), and marbling score (Slight⁴⁶ vs Slight⁶⁴) were lower and LT area (82.5 vs 78.6 cm²) was greater for those carcasses with < 5 mm adjusted fat thickness than for those carcasses with ≥ 5 mm adjusted fat thickness ($P < .01$; data not presented in tabular form).

The effect of fat thickness group (< 5 mm vs ≥ 5 mm) and marbling score on sensory attributes is presented in Table 2. Fat thickness group and marbling score interacted to affect shear force, overall tenderness, juiciness, and beef flavor intensity; however, the interactions seemed to be nonsensical. Increased fat thickness tended to result in less tender,

Table 2. Effect of fat thickness and marbling score on Warner-Bratzler shear force and sensory panel traits

Marbling score	Fat thickness group			Contrast	
				≥ 5 mm vs < 5 mm	≥ 5 mm vs Overall
	< 5 mm	≥ 5 mm	Overall		
No. of observations					
Traces or lower	76	8	84	—	—
Slight	392	400	792	—	—
Small	116	529	645	—	—
Modest or higher	7	74	81	—	—
Overall	591	1,011	1,602	—	—
Shear force, kg (RMSE ^a = 1.21)					
Traces or lower	6.05	6.17	6.06 ^f	NS ^j	NS
Slight	5.58	5.32	5.45 ^g	**	NS
Small	4.68	4.85	4.82 ^h	NS	NS
Modest or higher	4.38	4.27	4.28 ⁱ	NS	NS
Overall	5.45	5.00	5.17	***	**
Overall tenderness ^b (RMSE ^a = .68)					
Traces or lower	4.65	4.62	4.64 ⁱ	NS	NS
Slight	4.82	4.99	4.90 ^h	**	†
Small	5.26	5.20	5.21 ^g	NS	NS
Modest or higher	5.11	5.44	5.41 ^f	NS	NS
Overall	4.89	5.13	5.04	***	**
Juiciness ^c (RMSE ^a = .44)					
Traces or lower	4.98	4.60	4.95 ⁱ	NS	NS
Slight	5.05	5.12	5.09 ^h	NS	NS
Small	5.17	5.27	5.25 ^g	NS	NS
Modest or higher	5.29	5.48	5.46 ^f	NS	NS
Overall	5.07	5.22	5.17	***	**
Beef flavor intensity ^d (RMSE ^a = .43)					
Traces or lower	4.81	5.04	4.83 ^g	NS	NS
Slight	4.85	4.86	4.86 ^g	NS	NS
Small	4.94	4.97	4.96 ^f	NS	NS
Modest or higher	4.44	4.97	4.92 ^{fg}	**	NS
Overall	4.86	4.92	4.90	*	NS
"Slightly tender" or higher frequency, % ^e (RMSE ^a = 48.1)					
Traces or lower	42.1	37.5	41.7 ^g	NS	NS
Slight	45.4	52.0	48.7 ^g	NS	NS
Small	73.9	67.7	68.8 ^f	NS	NS
Modest or higher	71.4	82.4	81.5 ^f	NS	NS
Overall	50.9	62.3	58.1	**	*

^aRMSE = Root mean square error. The standard error of a least squares mean can be determined by dividing the RMSE by the square root of the number of observations.

^b8 = extremely tender; 1 = extremely tough.

^c8 = extremely juicy; 1 = extremely dry.

^d8 = extremely intense; 1 = extremely bland.

^ePercentage of samples rated "slightly tender" or higher for overall tenderness.

^{f,g,h,i}For a given trait, means within a column lacking a common superscript letter differ ($P < .05$).

^jNS = not statistically significant ($P \geq .10$).

[†] $P < .10$.

* $P < .05$.

** $P < .01$.

*** $P < .001$.

drier beef for the marbling scores of "traces" and "small," whereas increased fat thickness resulted in more tender steaks for carcasses with a "slight" amount of marbling. There was no interaction between fat thickness group and marbling score on the percentage of steaks rated "slightly tender" or higher by a trained sensory panel. When data were pooled across all marbling scores, WBS values were higher

($P < .001$) and overall tenderness ($P < .001$), juiciness ($P < .001$), beef flavor intensity ($P < .05$) and the percentage of samples rated "slightly tender" or higher for overall tenderness ($P < .01$) were lower for carcasses with < 5 mm s.c. fat thickness than for those with ≥ 5 mm s.c. fat thickness. Among carcasses with a "slight" amount of marbling in the ribeye, the effect of fat thickness group on WBS values and TSP

ratings was smaller and less significant. Consequently, when those carcasses qualifying for the current Select grade (fat thickness group = "overall" and marbling score = "slight") were contrasted against those carcasses qualifying for the proposed Select grade (fat thickness group = " ≥ 5 mm" and marbling score = "slight"), it was noted the current and proposed Select grades did not differ with respect to shear force, overall tenderness, juiciness, beef flavor intensity, or the percentage of samples rated "slightly tender" or higher for overall tenderness.

Simple correlation coefficients (data not presented in tabular form) indicated that adjusted s.c. fat thickness accounted for less than 5% of the variation in WBS force, overall tenderness, juiciness, and beef flavor intensity ($r = -.17, .15, .18$, and $.08$, respectively). Similarly, marbling score accounted for less than 10% of the variation in WBS force, overall tenderness, juiciness, and beef flavor intensity ($r = -.32, .26, .26$, and $.10$, respectively).

Because there is an association between fat thickness group and marbling score and marbling score is more highly correlated with tenderness than is fat thickness, we chose to examine the effects of fat thickness on tenderness when marbling score was held constant. For the sake of simplicity, we chose to include only carcasses with a "slight" amount of marbling in this analysis. Carcasses were selected from the original data set in pairs with respect to degree of marbling (scored to the nearest 10 degrees) with one member of each pair in each fat thickness group. Thus, there was an equal number of carcasses in each fat thickness group, and the distribution of marbling scores was the same for each fat thickness group. There were 286 pairs of carcasses available for this comparison. Overall tenderness was the only trait that differed between fat thickness groups. This data suggested that fat thickness has, at most, a very small effect on the tenderness of Select grade beef.

Discussion

A major limitation to the development of a value-based marketing system for beef has been the mixture of economic signals between the various segments of the beef industry. Although the consumer has a clear preference for beef with little or no external fat (Savell et al., 1989), retailers and restaurateurs have continued to pay a premium for highly-marbled beef. This in turn has resulted in some cattle being overfatted to ensure that a relatively high percentage of carcasses have a sufficient amount of marbling to grade USDA Choice. The recent increase in the acceptance of packer-trimmed subprimals by the beef retail and foodservice industries and the implementation of hot-fat trimming by a major beef packer clearly signal the beginning of the value-based marketing era

for the U.S. beef cattle industry. It is likely that if a minimum fat thickness is required for carcasses to grade USDA Select, packers will be forced to either 1) encourage the production of cattle with a minimum of 5 mm of external fat or 2) discontinue the use of the USDA quality grading system, particularly for the USDA Select grade.

Lorenzen et al. (1993) reported that the average beef carcass in 1991 had a 15.0-mm 12th rib fat thickness. Savell et al. (1991) documented that the average beef retail cut had just 3.1 mm of external fat cover. Thus, there is a large amount of fat that must be trimmed from most beef cuts before retail marketing. Clearly the U.S. beef industry must strive to decrease the production of excess trimmable fat. This is not likely to occur if minimum levels of fatness are required for one or more of the USDA quality grades.

Similarly, the popularity of Select grade beef may decrease if the grade loses its lean image. Because the name of the grade was changed from "Good" to "Select" in 1987, the proportion of quality graded carcasses being graded Good/Select has increased from 2 to 28% (USDA, 1993). Select must continue to be composed of lean beef if it is to meet the diet/health-conscious consumer's need for nutritious, palatable meat.

In the present experiment, fat thickness group was found to significantly affect meat tenderness. However, the magnitude of this difference was small (.24 units on an 8-point scale), suggesting that, although these differences may be statistically significant, the effect of s.c. fat thickness on meat tenderness may not be practically important. In fact, the current and proposed Select grades did not differ in any of TSP traits. The beef industry must weigh the evidence and determine whether achieving such a small (3.3%) increase in the percentage of steaks rated "slightly tender" or higher is worth sacrificing the lean image of Select. Results of the National Consumer Retail Beef Study (Savell et al., 1989), in which one-half of the consumers showed a clear purchase preference for beef of the Select grade (even when it was priced higher than beef of the Choice grade) because of its superiority in lean:fat ratio, suggest that adding a minimum fat thickness requirement to the Select grade may be counterproductive.

Riley et al. (1983) reported that steaks from bullock carcasses with 6.4 mm or less s.c. fat thickness were less tender than those with 6.5 mm or greater s.c. fat thickness. However, they demonstrated that these small differences in tenderness could be eliminated by electrical stimulation. This point should be considered in detail as the USDA, Agricultural Marketing Service contemplates changes in the beef quality grading system because virtually all U.S. beef packers use some form of electrical stimulation, although these systems vary considerably.

The present study does not support the presence of an interaction between marbling score and s.c. fat thickness group reported by Tatum et al. (1982).

Because of the specifics of the quality grading changes considered by the CQTF, we did not use the same s.c. fat thickness groups as Tatum et al. (1982). However, for the sake of comparison, we conducted a separate analysis (data not presented) using the same s.c. fat thickness groups as Tatum et al. (1982) and, once again, we found that our data did not support their findings.

Studies of the effect of hot-fat trimming, in which contralateral beef sides were either trimmed or untrimmed, have demonstrated conclusively that s.c. fat cover is not necessary to ensure tenderness of aged beef (Koohmaraie et al., 1988; Ahmed et al., 1991). Koohmaraie et al. (1988) found that when carcasses were exposed to the most extreme chilling conditions (trimmed of all s.c. fat cover and chilled at 0°C), hot-fat-trimmed sides were less tender at 1 d postmortem; however, following 14 d of cooler aging, the trimmed sides were slightly more tender than the untrimmed sides. The relationships noted between s.c. fat thickness and beef tenderness reported in this and other studies (Bowling et al., 1977; Dolezal et al., 1982; Tatum et al., 1982; Riley et al., 1983) were likely a reflection of the relationship between s.c. fat thickness and other factors that influence tenderness (e.g., preslaughter feeding regime and/or breed). In the present experiment, when marbling score was held constant, the effect of fat thickness on meat tenderness was very small. A comparison of the results

presented in Table 2 (in which marbling was held constant) and those presented in Table 3 (in which marbling was not held constant) suggested that most of the improvement in tenderness associated with increased fat thickness was a result of other factors (such as marbling) that affect tenderness and not a direct effect of fat thickness.

Implications

The addition of a minimum 5-mm adjusted fat thickness requirement to the USDA beef quality grading standards for the Select grade would not significantly improve the tenderness of Select beef. Moreover, this grading change could possibly discourage the production of lean beef. Thus, active pursuit of this proposed change to the USDA beef quality grading system would be counterproductive.

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Table 3. Effect of fat thickness group on Warner-Bratzler shear force and sensory panel traits of Select carcasses when marbling was balanced across fat thickness groups^a

Trait	Fat thickness group		SEM
	< 5 mm	≥ 5 mm	
No. of observations	286	286	
Shear force, kg	5.59	5.41	.08
Overall tenderness ^b	4.80 ^g	4.93 ^f	.04
Juiciness ^c	5.04	5.08	.03
Beef flavor intensity ^d	4.84	4.87	.02
"Slightly tender" or higher frequency, % ^e	43.7	50.0	2.9

^aCarcasses were selected from the original data set in pairs with respect to degree of marbling (scored to the nearest 10 degrees) with one member of each pair in each fat thickness group. Thus, there were an equal number of carcasses in each fat thickness group, and the distribution of marbling scores was the same for each fat thickness group.

^b8 = extremely tender; 1 = extremely tough.

^c8 = extremely juicy; 1 = extremely dry.

^d8 = extremely intense; 1 = extremely bland.

^ePercentage of samples rated "slightly tender" or higher for overall tenderness.

^{f,g}Means within a row lacking a common superscript letter differ ($P < .05$).

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